

(NASA-CR-194846) IMPROVED
SATELLITE SIGNALS IN TROPICAL
FORECASTS IN THE NMC MEDIUM RANGE
FORECAST MODEL (Texas A&M Univ.)
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IMPROVED SATELLITE SIGNALS IN TROPICAL FORECASTS
IN THE NMC MEDIUM RANGE FORECAST MODEL

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1. INTRODUCTION

Tropical analysis and synoptic scale forecasting suffer due to a lack of observations. The observational network is composed primarily of retrieved satellite temperature soundings, isolated surface observations and sporadic cloud drift winds, where appropriate clouds exist. Since temperature carries little synoptic signal in the tropics, model grid points over the eastern Pacific tropics can go for many days without a single local meaningful observation. In these cases, the analyzed fields revert to model climatology. As tropical systems develop, no information is obtained until trackable clouds develop; if these observations diverge greatly from the model climatology, their effect may be minimized for one or two analysis/forecast cycles.

McGuirk and Ulsh (1990) and McGuirk (1989) describe three synoptic scale signals observed by operational polar orbiting and geostationary satellites. These features are associated with the development of tropical synoptic scale systems called tropical plumes. The features are: 1) a planetary-scale, tropospheric-deep thermal wave which drifts slowly eastward and is resolved by operational analysis; 2) a 3000 km thermal wave which is equivalent barotropic of vertical mode 2 or 3, and propagates eastward; and 3) a 5000 km moisture wave which is the tropical plume. These features exist 24 to 48 h before clouds develop and interact in the early stages of tropical plume development. Often, plumes are not well analyzed or forecast by operational systems. This research demonstrates for a single case study that, if these signals are included in the NMC global spectral model initialization, the 48-h tropical plume forecast is improved. Verification is conservative in that NMC analyses, valid at 48 h, are used as verification; in data sparse regions, these analyses will be dominated by the model forecast itself.

2. EXPERIMENT DESIGN

48-h integrations were carried out with the NMC global spectral model, initialized to 00 UTC 16 January 1989 for a tropical plume which developed at 00 UTC 18 January at approximately 145°W. Temperature and moisture signals were extracted directly from NOAA 8 and 9 observed brightness temperatures, available on NMC operational history tapes; these signals were used to perturb the historical initialization. Temperature structure of the perturbation is fit to analytic functions regressed statistically onto the brightness temperatures. Vertical structure peaked at 500 and 125 mb, approximately. Zonal structure was 3 sine waves with a wavelength of 34°, tapered to zero to the east and west to avoid shocking the model. Meridional structure was fit to an order 2 parabolic cylinder function with a lateral scale of

20°. Given the limited ability to infer tropical moisture, a heavy-handed approach was selected. At each point where the 7.3 micrometer moisture channel was less than -14°C (moist), the analyzed relative humidity was increased by 15% throughout the tropospheric column; relative humidities greater than 100% were not allowed.

The resulting initial temperature and moisture perturbations are shown in Fig. 1a. Fig. 1b shows the initial 200 mb wind field, for reference; initial wind fields were not perturbed. Noted are the sharp mid latitude trough, the two jet maxima near 150°W and the vortex west of the dateline. The tropical plume developed at point X and reached maturity 48 h later. A number of 48 h forecasts were conducted. The historical forecast was reproduced to provide a baseline. Forecasts with temperature and moisture perturbations individually and together were run. Only the base experiment with both temperature and moisture perturbations inserted before initialization is described herein.

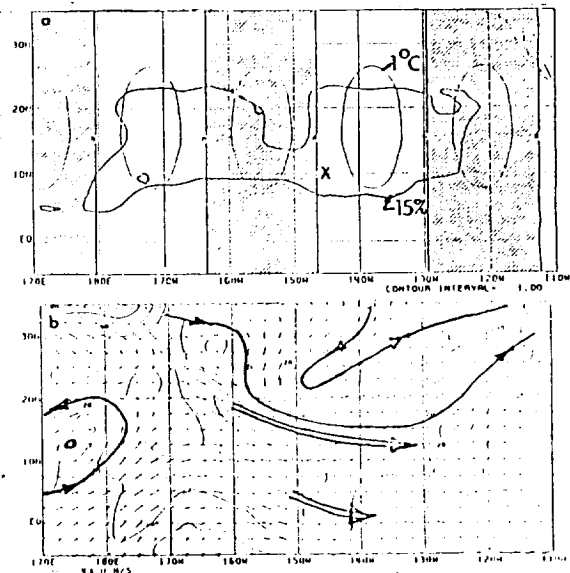


Fig. 1. (a) Horizontal pattern of initial temperature (shading is negative) and relative humidity (heavy line) perturbations based on satellite brightness temperatures. (b) Initial 200 mb wind vectors and isotachs. Heavy lines for emphasis.

3. RESULTS

The results are summarized in Figs. 2, 3 and 4. The (a) portions show the 48-h forecast error, or difference between the forecast and the historical verification. The (b) portions show the corrections to the 48-h forecast resulting from forecasts from the perturbed fields.

Fig. 2 displays the 200 mb height error and correction fields. The historical NMC model made

a 100 m height error in a wave centered at 28°N. The satellite signals were not expected to correct mid latitude errors and they did not. However, the wave train along 10-15°N was improved. Some of the inserted satellite signal was damped during initialization, so only about half of the error was corrected. The dominant improvement occurred near the plume origin region. The improvement within the vortex west of the dateline was an unanticipated success.

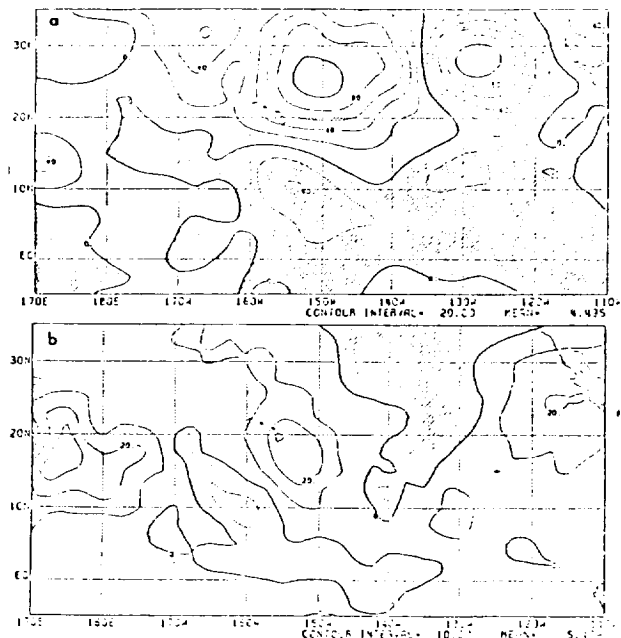


Fig. 2. Historical 48-h forecast 200 mb height error (a) and forecast correction from perturbed initial conditions (b) (negative for comparison). Contour interval is 20 m in (a) and 10 m in (b). Shading is negative.

The wind field errors and corrections are shown in Figs. 3 and 4. Winds along the equator and in the subtropics are not improved markedly. However, wind changes close to the synoptic disturbances throughout the east Pacific have modifications generally in the right direction. The vector scales are different in the (a) and (b) portions, so the corrections are only half as large as they should be. The vortex west of the dateline was too anticyclonic (cyclonic) at 200 (850) mb. This feature, as well as the meridional flow to its southwest, was improved at both levels. The cyclonic/anticyclonic couplet associated with the tropical plume was improved in both the upper tropospheric and lower tropospheric flow.

4. DISCUSSION

Operationally available satellite signals, too small to survive operational retrieval processing, can be extracted by accounting for their horizontal structure and coherence. These synoptic scale signals improve tropical analysis and forecasting under certain conditions, specifically for eastern Pacific tropical plumes as resolved and forecast by the NMC global spectral model.

5. REFERENCES

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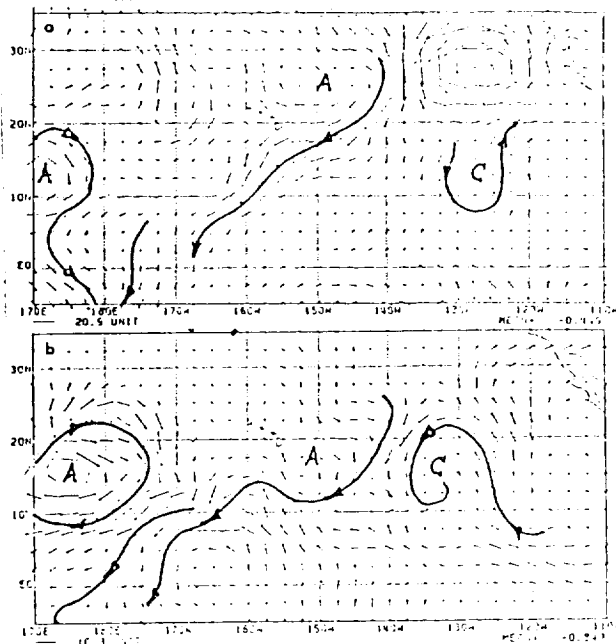


Fig. 3. As in Fig. 2, except for 200 mb wind vectors. Vector scale in (b) is approximately 50% of that in (a). Heavy lines for emphasis.

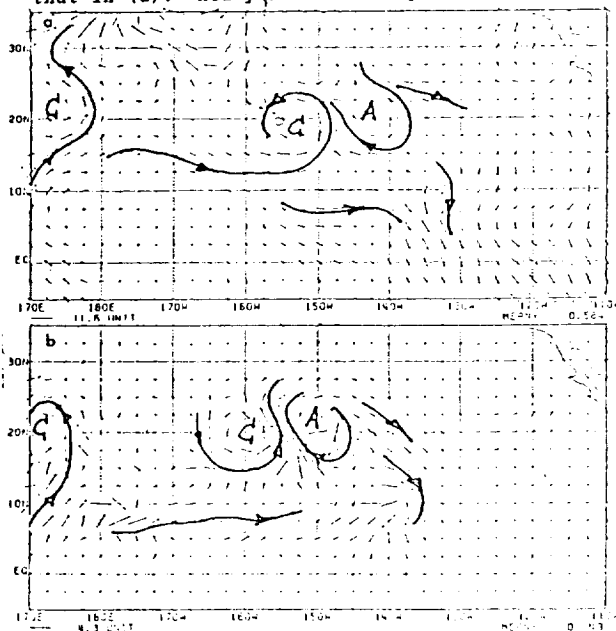


Fig. 4. As in Fig. 3, except for 850 mb. Vector scale on (b) is approximately 40% of that in (a).